Redescription and ecological notes on *Simulium* (*Simulium*) *nikkoense* (Diptera: Simuliidae) firstly recorded from Xinjiang

Gang WANG, Huan GUO, Shutian ZHANG, Min HUANG①

Key Laboratory of Plant Protection Resources and Pest Management of the Ministry of Education; Entomological Museum, Northwest A&F University, Yangling, Shaanxi 712100, China

Abstract: *Simulium* (*Simulium*) *nikkoense*, a species of black fly that is known to bite humans, has been collected in Xinjiang for the first time. Here the larvae, pupa, female and male are re-described and illustrated. The distribution, biology, and medical importance of this species are also discussed.

Key words: black flies; description; new record

新疆新纪录樱花蚋再描记及生态学记述（双翅目：蚋科）

王刚，郭欢，张树田，黄敏①

植保资源与病虫害治理教育部重点实验室，西北农林科技大学昆虫博物馆，陕西 杨凌 712100

摘要：首次报道新疆 1 种刺叮性蚋科医学昆虫——樱花蚋，对其雄虫、雌虫、蛹以及幼虫进行了重新描述并附特征照片。并对其分布，生物学以及医学重要性进行了讨论。

关键词：蚋；描记；新纪录

Introduction

Black flies rank second in medical and veterinary importance among insects (Currie & Adler 2008). Thus far, 333 species are known from China (Chen 2016) and they are widely distributed across China. Female black flies bite and swarm around birds and mammals, reducing productivity (Crosskey 1990; Adler *et al*. 2004). Although black flies occur throughout the country, few have been reported for biting humans, and most of the biting species cannot be accurately identified (Lin *et al.* 2008； Lan *et al*. 2017; Li *et al.* 2012; Wang *et al*. 2013; Zhang *et al*. 2006; Li 1976).

Shiraki (1935) described *Simulium nikkoense* as a new species. Takahasi (1959), Sun (1994), Chen & An (2003), Chen (2016) respectively redescribed the species distributed in Japan and China, and more recently, Kim (2015) redescribed the larvae and pupa from Korea. According to the above descriptions, there are morphological varieties among different geographical populations of *Simulium nikkoense*. Accurate identification is the basis for the taxonomy of medical insects and prevention strategies, but a comprehensive description of *Simulium nikkoense* with accurate figures still has not been reported. In this paper, the female,

Accepted 19 November 2017. Published 25 December 2017. Published online 24 December 2017.

① Corresponding author, E-mail: huangmin@nwsuaf.edu.cn

male, and pupa of *Simulium nikkoense* are fully re-described and digitally illustrated based on material collected in Xinjiang. Its distribution, biology, and medical importance also be presented.

Material and methods

The classification system and morphological terminology used follow that of Adler (2004). The techniques for collection, rearing, dissection are those detailed by Adler (2004). External morphology was examined under a dissecting microscope (Leica EZ4). Preparations were examined by microscopy (Nikon E200). Consecutive digital images were taken using a Zeiss Discovery V20 (Car Zeiss Microlmaging, Germany) stereo microscope with a digital camera (Zeiss Mcr camera) and the images were Z-stacked using ZEN software. Voucher specimens are deposited in the Entomological Museum, Northwest A&F University, Yangling, Shaanxi, China.

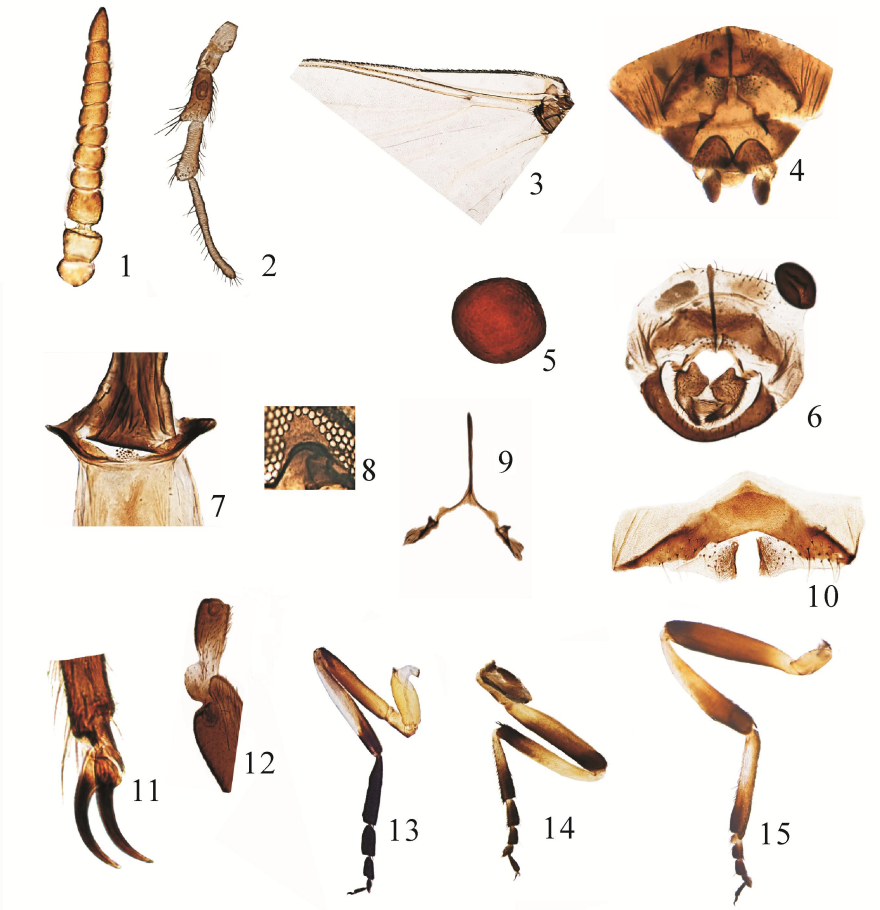
Diagnosis. This species are most similar to *Simulium* (*Simulium*) *noelleri* and *Simulium* (*Simulium*) *palustre*, but can be distinguished from them by the combination of the following characteristics: larval head spot positive but seemingly negative with dark surrounding areas, postgenal cleft lanceolate with apex extended to hypostomal groove; ventral most filaments with long petiolate stalk. Male genitalia, equilateral triangle-shaped.

Taxonomy

Female (Figs. 1–15). General color black; body mean length (from anterior region of head to abdomen tip) 3.26 mm (SD = 0.08, n = 5); lateral thorax mean length (from neck to wing base) 1.45 mm (SD = 0.04, n = 5). Wing mean length 2.68 mm (SD = 0.1, n = 5). Frons brown; clypeus brown with silver pruinosity; frons longer than wide, with greyish white hairs; frontal ratio 6.8 : 6.5 : 8; fronto-ocular suture absent, fronto-ocular triangle as in Fig. 8. Antenna mean length 0.58 mm (SD = 0.03 n = 5); scape, pedicel and 1/2 of the first flagellomere brownish yellow, subsequent flagellomeres increasingly dark brown (Fig. 1). Palpus dark brown; sensory vesicle length more than half the length of palpomere III (Fig. 2), palpomere V 2.2 times as long as palpomere III and 1.8 times as long as palpomere IV (Fig. 2). Mandible with 10, 11 weak external serrations and 21, 22 internal teeth. Maxilla with about 8–12 inner teeth and about 13–16 outer ones. Cibarium with sclerotized cornuae, medial area with a group of minute (Fig. 7). Scutum black, grey pruinose, covered with whitish yellow pubescence and with anterior pair of silvery white spots on shoulders. Anepisternum and katepisternum brown with silver pruinosity. Scutellum brown, with gold and brown hairs; postnotum brown, with silver pruinosity.

Wing costa with spiniform and hair-like setae (Fig. 3). Foreleg (Fig. 13) with coxa, trochanter, 4/5 femur and 1/2 region of tibia pale yellow; basal and distal regions of tibia light brown; basitarsus and tarsomeres dark brown. Middle leg (Fig. 14) with coxa brown, 2/3 of femur, 1/3 of trochanter, distal 1/2 of basitarsus, basitarsus and tarsomeres I–IV brown, distal region of tarsomeres I and remainder of middle leg pale yellow. Hind leg (Fig. 15) with distal 4/5 of femur, distal 2/3 of tibia, distal 1/2 of basitarsus, distal region 1/2 of tarsomeres I brown,

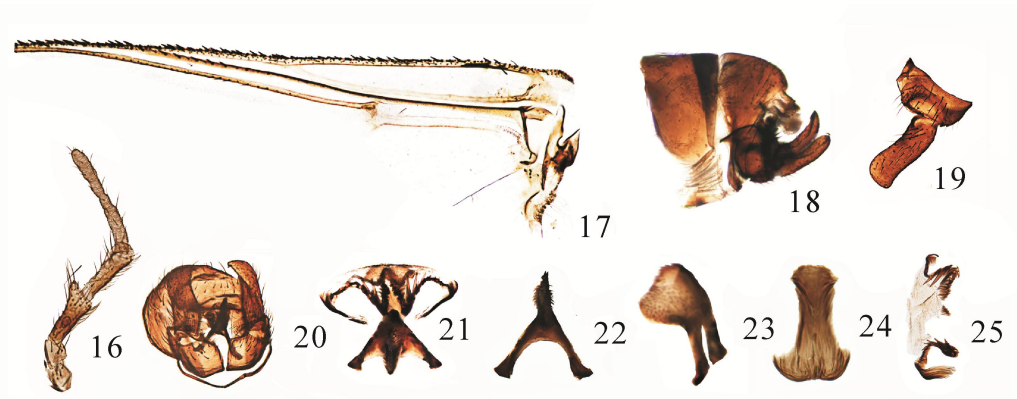
remainder of hind leg pale yellow; calcipala and pedisulcus well-developed (Fig. 12). Tarsal claws curved, without subbasal tooth (Fig. 11). Basal fringe, in the abdomen with long golden-whitish and brown hairs. Sternite VIII dark brown. In lateral view, cerci approximately as long as their base widths, long, base thick and top thin, covered with long thick setae (Figs. 4, 6). Sternite VIII sclerotised with irregularly distributed setae on posterior margin. Gonapophyses triangle shaped, well-developed, and not touching centrally , membranous, highly setose over entire surface. Genital fork (Fig. 9) with stem as long as lateral arms, apically expanded; lateral arms with inner margin concave and forming a V-shape at their insertion in the main stem; apodeme developed. Spermatheca oval, with cuticular microspines (Fig. 5).



Figures 1–15. Female of *Simulium nikkoense*. 1. Antenna; 2. Maxillary palp; 3. Wing base; 4. Female Cercus and anal lobe *in situ*, ventral view; 5. Spermatheca; 6. Female genitalia, ventral view; 7. Cibarium; 8. Fronto-ocular triangle; 9. Genital fork; 10. Genital plate; 11. Tarsal claw; 12. Calcipala and pedisulcus; 13. Fore leg; 14. Middle leg; 15. Hind leg.

Male. (Figs. 16–22). General body color black, body mean length, 2.81 mm (SD = 0.14, *n* = 5); lateral thorax mean length (from neck to anterior region of wing insertion) 1.32 mm (SD = 0.06, *n* = 5). Wing (Fig. 17) mean length 2.6 mm (SD = 0.09, *n* = 10). Antenna mean length

0.53 mm (SD = 0.04 mm, *n* = 5); scape and pedicel brownish yellow, subsequent flagellomeres increasingly dark brown. Palpus (Fig. 16) brown, palpomere V about 2.57 times as long as palpomere III and 1.99 times as long as IV; sensory vesicle small, subspherical, 1/3 scutellum brown with thin golden hairs. Postnotum brown with silver pruinosity. Wing similar to the female (Fig. 17). Abdominal basal fringe with thin, long brown hairs; tergites II, V–VII with lateral silver pruinosity. Gonocoxite and gonostylus (Figs. 18, 19, 20) brown, gonocoxite wider than long; gonostylus more than triple the gonocoxite length, longer than wide, bearing one spinule at the apex (Fig. 19). Ventral plate (Figs. 21, 22, 23), in ventral view, approximately equilateral triangle, with a median anterior projection covered with setae. Median sclerite as in Fig 24. Paramere with developed and sclerotized basal process and stout teeth, aedeagal membrane with spicules (Fig. 25).



Figures 16–25. Male of *Simulium nikkoense*. 16. Maxillary palp; 17. Wing base; 18. Male genitalia, lateral view; 19. Gonocoxite and gonostylus, lateral view; 20. Male genitalia, posterior view; 21. Ventral plate and paramere, ventral view; 22. Ventral plate, lateral view; 23. Ventral plate, lateral view; 24. median sclerite; 25. paramere and aedeagal membrane.

Mature larva (Figs. 26, 27A). Body length 8.696 mm (SD = 0.54, *n* = 10). Body (Fig. 27A) pale reddish brown with with variable banding pattern(Fig. 26). Head capsule (Fig. 27C) brownish yellow with brown to dark brown areas. head spots indistinctive and the area surrounding head spots darkly pigmented. Antenna pale yellowish brown, a little longer than labral fan stem. Labral fan (Fig. 27C) with 48, 49 primary rays. Postgenal cleft (Figs. 27B, 28C) deep, lanceolate, pointed, 1.36 times as long as wide, 5.4–6.2 times as long as postgenal bridge; usually tip of postgenal cleft irregularly extended toward the hypostomal groove, lateral elongate spot present, positive. Lateral surface of head

Figure 26. Larvae of *Simulium nikkoense*. Larvae lateral habitus; variations in banding pattern and cuticle color.

capsule (Fig. 27D) with positive spot under ocelli. Gill histoblast with 8 filaments (Fig. 28C). Hypostoma (Figs. 28A, 28C) with 7 apical teeth, 2 sublateral teeth indistinctive; median and lateral teeth prominent; sublateral teeth small, only 4 teeth visible; paralateral teeth not developed; lateral serrations well-developed; hypostoma with 3, 4 apically branched hypostomal setae. Mandibular teeth: one apical, two small external teeth, three subapical teeth, 8–10 internal teeth, one mandibular serration and one small mandibular sensillum.Posterior proleg (Fig. 28B) with 12, 13 hooks in about 63–65 rows. Rectal papillae (Figs. 27E, 27F) of 3 lobes, each with 7, 8 digit-like long secondary lobules.

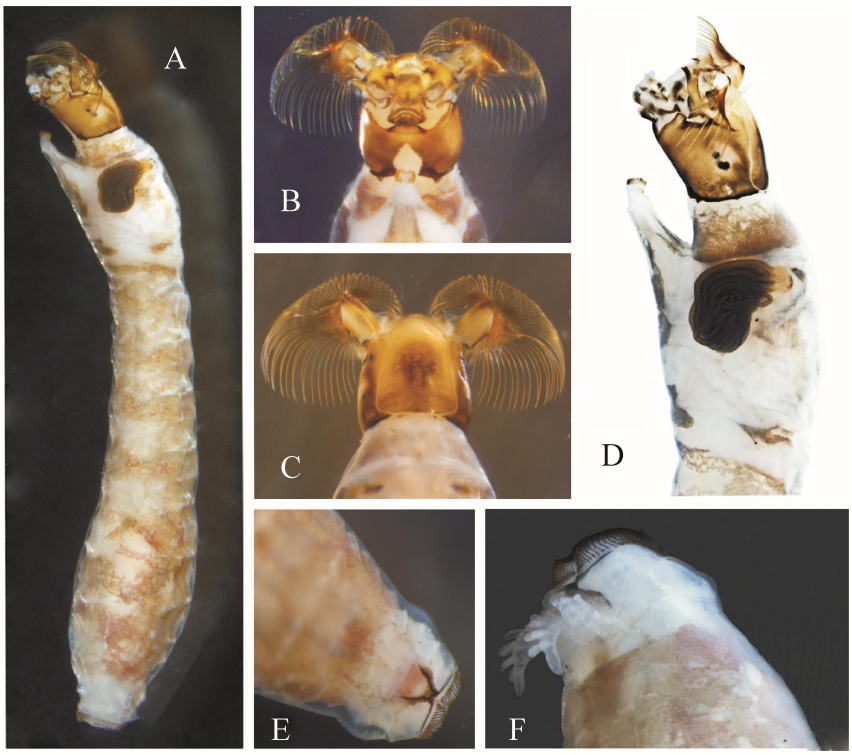


Figure 27. Larva of *Simulium nikkoense*. A. Larva, lateral view; B. Larval head, dorsal view; C. Larval head, ventral view; D. Larval head and gill histoblast, lateral view; E. Anal sclerite. F. Rectal papillae.

Pupa (Fig. 29). Body length (excluding gill filaments) 4.415 mm (SD = 0.18, n = 10). Cocoon (Figs. 29A, 29B) slipper shaped with loosely woven rim, 5.3–6.8 mm long. Gill (Figs. 29C, 29D, 29G) with 8 filaments, 0.66 times as long as pupa, (2+1)+1+1+1+2 arrangement, arising from common short basal stem except for one ventral pairs with long petiolate stalks; basal most stalk longer than others; dorsal-most filament directed upwardly then forward. Cephalic plates and thorax (Figs. 29C, 29D) densely covered with small tubercles. Abdomen (Figs. 29E, 29F, 29H) with each side of abdominal tergites III and VI with 4 anteriorly directed spine-like hooks on posterior margin; segment V bare; segment VI with very small spiny comb; segments VII–VIII with row of spines on comb; terminal hooks well-developed.

Specimens examined. China, Xinjiang, Beitun. 47°26'18.28 N, 87°33'36.12" E, 7♂6♀, 12 mature and 10 immature larvae, 8 pupa; Fuhai, 46°36' 31.36" N,87°51'47.93"E, 7♂8♀, 15

mature and 11 immature larvae.

Distribution. China (Xinjiang; Inner Mongolia; Jilin; Liaoning); Japan (Hokkaido; Honshu; Kyushu; Shikoku); Korea (South).

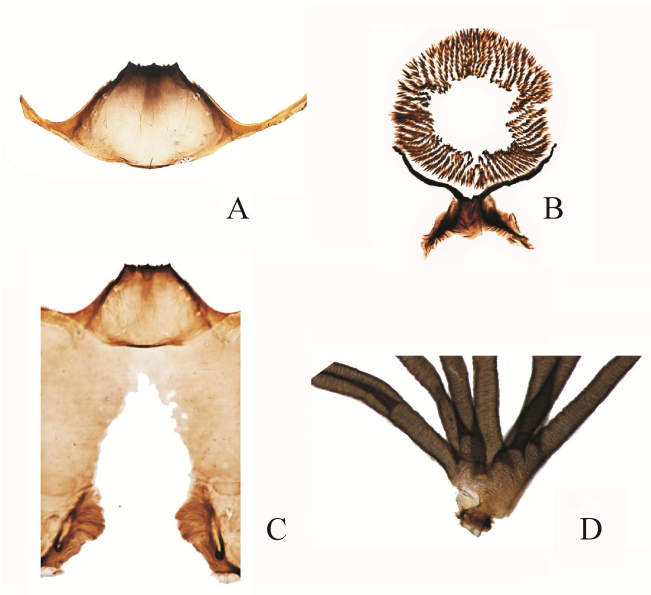


Figure 28. Larva of *Simulium nikkoense*. A. Larval hypostoma; B. Anal sclerite and posterior circlet; C. Larval gill filaments.

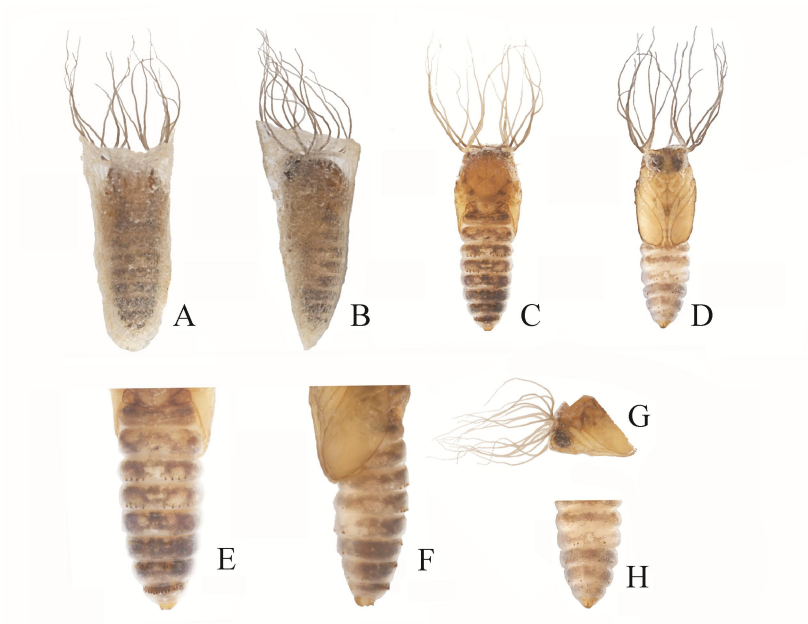


Figure 29. Pupa and cocoon of *Simulium nikkoense*. A. Pupa and cocoon, dorsal view; B. Pupa and cocoon, lateral view; C. Pupa, dorsal view; D. Pupa, ventral view; E. Pupal abdomen, dorsal view; F. Pupal abdomen, lateral view; G. Pupal head, lateral view; H. Pupal abdomen, ventral view.

Remarks. The examined specimens fit well with the descriptions of Chen (2013 & 2016) and Sun (1994). Additional morphological diagnostic variations are shown in Table 1.

Table. 1 Morphological varieties of *Simulium nikkoense* from three different collection sites

	Korea[a]	Liaoning & Inner Mongolia, China[b]	Xinjiang, China
Body length(mm)			
Female	–	2.3–3.8	3.14–3.73
Male	–	2.5–4.2	2.81–3.98
Pupa	3.5–4.4	2.5-4.0	4.10–4.60
Mature larva	6.9–8.1	5.2-6.2	8.21–9.12
Posterior proleg			
Hooks/Row	11–13	10–11	12–13
Rows	66–68	57–64	63–65
Labral fan			
Primary rays	45–46	42–46	48–49
Filament arrangement	(1+1+1)+1+(2+2)	(1+2)+(1+2)+2	(2+1)+1+1+1+2

a: based on Kim (2015); b: based on Sun (1994)

Ecological notes. Most specimens were collected in two rivers approximately 5 m (Fuhai) and 12 m (Beitun) in width. Water temperatures ranged from 20 to 24.2° C, pH from 7.74 to 7.94, and electrical conductivity from 122 to 356 us/cm. The streambeds were composed of sand and boulders. Larvae and pupae were collected on submerged tree branches and leaves from riparian vegetation, hanging from the banks or trapped between boulders, in fast-flowing water. The females of this species were collected biting humans during the fieldwork.

Medical importance. Bentinck (1955) stated that the females of *Simulium nikkoense* bite humans in Japan. We also found that *Simulium nikkoense* bites and swarms around humans, causing potential for both disease transmission and injuries to human health in the Irtysh river basin. Black flies bites cause a variety of different reactions in humans, ranging from a small puncture wound where the original blood meal was taken to a swelling that can be the size of a golf ball. Reactions to black fly bites, collectively known as “black fly fever”, include headache, nausea, fever and swollen lymph nodes in the neck (Hill 2008).

Acknowledgments

We are grateful to Peter H. Adler (Professor, Clemson University, Clemson, SC) for examining the larvae pictures and John Richard Schrock for linguistic support. Thanks for the support and help of Science and Technology Bureau of the 10th Division of Xinjiang Production and Construction Corps and Institute of Agricultural Sciences of the 10th Division of Xinjiang Production and Construction Corps. This work was supported by National science and technology Huimin project (2013GS650305), Research Fund for the Doctoral Program of Xinjiang Production and Construction Corps (2013BB017) and Science and Technology

Bureau of Xinjiang Production and Construction Corps (2012BAH12B03).

References

Adler PH, Currie DC & Wood DM. 2004. *The Black Flies* (*Simuliidae*) *of North America*. Cornell University Press, Ithaca, NY, USA, 41 pp.

Bentinck WC. 1955. *The Black Flies of Japan and Korea* (*Diptera: Simuliidae*). Department of Entomology, 406th Medical General Laboratory and Far East Medical Unit, 8003 Army Unit, San Francisco, 28 pp .

Chen HB. 2016. *Chinese Blackflies* (*Diptera: Simuliidae*). Guizhou Science and Technology Publishing House, Guiyang, 673 pp.

Chen HB & An JY. 2003. *The Blackflies of China*. Science Press, Beijing, 318 pp.

Crosskey RW. 1990. *The Natural History of Blackflies*. John Wiley & Sons, London, 722 pp.

Currie DC & Adler PH. 2008. Global diversity of black flies (Diptera: Simuliidae) in freshwater. *Hydrobiologia*, 595: 469–475.

Hill C, Platt J & Macdonald J. 2008. Black flies: biology and public health risk. Purdue Extension, E-251-W, Public Health, Department of Entomology, Purdue University. Available from: http://www.ces.purdue.edu/new, (Accessed 1 December 2017)

Kim SK. 2015. Morphology and ecological notes on the larvae and pupae of *Simulium* (*simulium*) from Korea. *Animal Systematics Evolution & Diversity*, 31(4): 209–246.

Lan YQ, Zhang XP, Huang JB & Zhang S. 2017. A biting accident by blackflies occurred in Lishui city, Zhejiang province. *Chinese Journal of Vector Biology & Control*, 28(1): 87–89.

Li XM, Bai JM, Hao HW, Yuan ZL, Wang GZ & Chang ZJ. 2012. Investigation and analysis of a biting accident by black flies. *Chinese Journal of Hygienic Insecticides & Equipments*, 18(3): 237–238.

Lin LH, Huang JL, Liu JF, Liu JH, Li Y & Fang MY. 2008. Investigation of biting dermatitis by blackflies. *Chinese Journal of Vector Biology & Control*, 19(3): 252–253.

Shiraki T. 1935. Simuliidae of the Japanese Empire. *Memoirs of the Faculty of Science and Agriculture*, 16: 1–90.

Sun YX. 1994. *Black Flies in Most Part of North China*. Fushun, Liaoning, 228 pp.

Takahasi H. 1959. Family Simuliidae. *In*: Kawada T (Ed.), *Illustrated Insect Larvae of Japan*. Hokuryukan, Tokyo, pp. 633–637.

Wang GZ, Li XM, Gu ZQ, Yuan ZL & Lv MJ. 2013. The Investigation and Analysis of 2 Bite Events by Unknown Bugs. *Henan Journal of Preventive Medicine*, 24(1): 67–68.

Zhang GL, Liu B & Han ZX. 2006. Investigation on the harm of mosquitoes and black flies to officers and soldiers health of Xinjiang frontier defence army. Chinese Journal of Hygienic Insecticides & Equipment, 12(3): 185–186.